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(54) **A magnetic resonance imaging system for tracking a medical appliance**

Magnetisches Resonanzdarstellungssystem zur Verfolgung eines Arzneigeräts

Système de représentation par résonance magnétique pour poursuivre un appareil médical

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(56) References cited:
EP-A- 0 091 577 **EP-A- 0 300 147**
DE-A- 3 937 052 **US-A- 5 271 400**

- **IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, vol.40, no.12, December 1992, NEW YORK US pages 2243 - 2250 J.C. CAMART ET AL. 'Coaxial Antenna Array for 915 MHz Interstitial Hyperthermia: Design and Modelization-Power Deposition and Heating Pattern - Phased Array'**

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Description

This invention relates to a magnetic resonance imaging system for tracking a medical appliance, comprising means for performing magnetic resonance imaging procedures on a body, whereby electromagnetic waves in radio-frequency and magnetic field gradient pulses are generated and transmitted into the body to induce a resonant response signal from selected nuclear spins within the body, said system comprising a wire antenna detecting magnetic resonance response signals, the antenna being intended to be included into the medical appliance and intended to be inserted into the body for obtaining a positional picture of the antenna which can be superposed with a magnetic resonance image of the body for calculating the position of the antenna in the body.

Tracking of catheters and other devices positioned within a body may be achieved by means of a magnetic resonance imaging system in order to avoid using X-rays and the risk of accumulated X-ray dose to the patient and long term exposure to the attending medical staff.

Typically, such a magnetic resonance imaging system may be comprised of magnet means, pulsed magnetic field gradient generating means, a transmitter for electromagnetic waves in radio-frequency, a radio-frequency receiver, a processor, and a controller. The device to be tracked contains in its end a small coil of electrically conductive wire. The patient is placed into the magnet means and the device is inserted into the patient. The magnetic resonance imaging system generates electromagnetic waves in radio-frequency and magnetic field gradient pulses that are transmitted into the patient and that induce a resonant response signal from selected nuclear spins within the patient. This response signal induces current in the coil of electrically conductive wire attached to the device. The coil thus detects the nuclear spins in the vicinity of the coil. The radio-frequency receiver receives this detected response signal and processes it and then stores it with the controller. This is repeated in three orthogonal directions. The gradients cause the frequency of the detected signal to be directly proportional to the position of the radio-frequency coil along each applied gradient. The position of the radio-frequency coil inside the patient may therefore be calculated by processing the data using Fourier transformations so that a positional picture of the coil is achieved. Since however the coil only reacts, literally not a positional picture of the coil but in fact a positional picture of the position of the response signals inside the patient is achieved. Since this positional picture contains no information yet on the region surrounding the immediate vicinity of the coil, this positional picture can be superposed with a magnetic resonance image of the region of interest. In this case the picture of the region may have been taken and stored at the same occasion as the positional picture or at any earlier occasion.

US Patent N° 5271400 illustrates such a technology.

Radio-frequency antennas in the form of a coil couple inductively to the electromagnetic field and they allow obtaining a substantially spatially uniform magnetic field which results in a relatively uniform image intensity over a wide region. The problem is however that coil configurations are bulky (the received signal is determined by the loop diameter), and the fact that they are contained in the device to be tracked adds to that, whereby they cannot be implemented for use in narrow vessels, and their use for the placement of medical appliances such as catheters may be critical. Furthermore, the spot image which is provided for by the coil antenna does not allow knowing or even evaluating the orientation of the device; as a result, the magnetic resonance imaging system cannot be used for steering the device into tortuous areas such as blood vessels.

European Patent N° 0165742 describes a catheter for use with magnetic resonance imaging systems. This catheter comprises a sheath which has embedded within the wall thereof a pair of conductors preferably formed of a foil composite obtained by plating of conductive materials of selected magnetic susceptibility to yield a composite of desired susceptibility substantially matching that of the sheath. In this way, the magnetic invisibility of the catheter is maintained. The tip of the catheter contains a loop connecting the conductors, the plane of such a loop being preferably transverse to the catheter symmetry axis. As explained in the document, when excited by a weak pulse source, the loop supports a dipole magnetic field which locally distorts the magnetic resonance image providing an image cursor on the magnetic resonance imaging display, and a low magnetic susceptibility functional element such as a light pipe threaded into the catheter sheath allows direction of the catheter through selected blood vessels. The essence of this structure is thus the accurate location and monitoring of the catheter tip. However, this is achieved within the environment of a bulky configuration which cannot be advanced through narrow vessels and which cannot be steered by reference to the magnetic resonance imaging system.

The document WO 87/04080 shows surgical catheters composed of alternating annular segments of non-magnetic materials which are highly opaque to nuclear magnetic resonance examination and less opaque, respectively. These catheters have thin coatings of silicone rubber on their external surface as well as on the internal surface of their main central lumen. A plurality of further lumens are distributed circumferentially within the catheter wall and guidance wires are housed in said lumens, secured at the distal end of the catheter wall and coupled to a joystick at the proximal end of the catheter for individual tightening and relaxing to permit radial guidance of the distal end of the catheter. The central lumen of the catheter and still further secondary lumens

arranged in the catheter wall are for the distribution of various drugs or for surgical tools such as optic fiber for laser surgery or suturing devices or still stitching grippers. By these arrangements, location of the catheters is apparent under nuclear magnetic resonance examination, visually at the distal end. These structures are however bulky and they have the same drawbacks as outlined hereinbefore.

European Patent Application published under N° 0385367 shows an insertable prostate pick-up probe devised for being a nuclear magnetic resonance receiving device capable of imaging spectra from the human prostate and surrounding tissue; this probe may also be used as the transmit coil for radio-frequency excitation. This probe is intended to be used with an interface network providing the tuning, impedance matching, and decoupling functions, and including a connection to a magnetic resonance imaging scanner. The probe includes a shaft supporting a patient interface balloon at its distal end, comprising an inner balloon and an outer balloon, the inner balloon being capable of being inflated with air supplied through a lumen within the shaft. A non-stretchable plane formed of an adhesive backed cloth material partly covers the inner balloon and serves as a guide for a flexible receiving coil arranged between the inner balloon and the outer balloon, this coil being electrically connected to the interface via an insulated cable extending through the shaft. Upon inflation, the non-stretchable plane rises and forces the receiving coil and outer balloon against the region of interest so that the receiving coil is in position to receive the best possible radio-frequency signal from the region of interest. Special indentations forming a shell are provided on the outer balloon to act as coil positioners when the balloon is in its uninflated state so that the coil may be repeatedly positioned relative to the shell inside the outer balloon for numerous clinical inflation and deflation cycles. A colored stripe is marked on the shaft, possibly including a scale, for indicating the distance which the shaft has been inserted into the patient and also the radial orientation of the balloon for proper alignment with the region of interest. In operation, the probe is inserted while the patient interface balloon is in the uninflated state; the alignment stripe marked on the shaft is used to radially and longitudinally position the probe within the region of interest. Once the probe is correctly placed, the patient interface balloon is inflated and the receiving coil is forced against the region of interest. The probe is then connected to the interface network via the insulated cable. This particular arrangement of the radio-frequency coil does not reduce the bulk of the system which cannot be used for narrow or tortuous vessels. Furthermore, the system does not provide for any information as to orientation of the probe for steering purposes.

The document DE-3937052 A1 shows a biopsy tube for use in a magnetic resonance imaging procedure, comprising longitudinally extending coaxial conductor tubes separated by insulator tubes and extending the length of the biopsy tube. In a further embodiment, the conductor tubes are replaced by gutter like portions of coaxial conductor tubes which are separated by an insulator filling. In a still further embodiment, there is shown a radioactive seed enclosed in a tubular needle also containing a coaxial conductor suitable for transmitting electromagnetic waves in radio-frequency. Here again, the result is a bulky configuration which cannot be advanced to narrow vessels. In addition, that of assembly is substantially stiff, thereby further preventing the applicability of the instrument in tortuous vessels.

European Patent Application published under N° 0091577 refers to a technology which is not directed to or envisaged for magnetic resonance procedures. This document describes however the use of a metallic conductor embedded in a probe and the proximal end of which is connected to the input of an electromagnetic waves receiver. The probe is for insertion into the body of a patient. The system further comprises an emitter of electromagnetic waves which feeds a movable transmitting head. Upon insertion of the probe into the body, the transmitting head is energised by the emitter and it is moved over the body in directions perpendicular to the supposed direction of the probe. By these motions, the emitter may transmit a series of signals to the receiver via the metallic conductor embedded in the probe. These signals vary in intensity as a function of the distance between transmitting head and tip of the probe, whereby the strongest signal may indicate the position of the tip of the probe in the body. The metallic conductor may have various configurations such as a mere wire extending from the tip of the probe up to the receiver, an input-output loop arrangement of two wires parallely embedded in the probe at a distance from one another, a coil, four wires diametrically embedded in the probe at a distance from one another with their distal ends loop connected two by two, a two-wire twist embedded along the probe, or still a coil with one conductor straight and the other undulated. The metallic conductor may also be made of a dispersion of conducting particles within the probe or on its wall. That kind of structure is also stiff and bulky.

The document IEEE Transaction on Microwave Theory and Techniques, 40(1992), N° 12, pages 2243 to 2250, relates to microwave heating in cancer treatment in association with radiotherapy. For this purpose, microwave interstitial hyperthermia uses miniature antennas inserted in the same catheters implanted for brachytherapy, and the document outlines use of semirigid coaxial radiating antennas inserted in plastic catheters for transferring the microwave energy to the volume to be heated. This is also stiff and bulky.

The object of this invention is to improve the possibilities of using magnetic resonance imaging procedures by means of a magnetic resonance imaging system for tracking a medical appliance which is simple

and efficient, which may continuously provide a full information as to the position and orientation of the medical appliance which occupies a minimal space and which has a great flexibility so as to be capable of reaching narrow and tortuous vascular configurations, which may be actually steered under magnetic resonance imaging, which may be used as an interventional means, and which may also prove efficient in the determination of the vascular configurations.

To this effect, the system according to the invention complies with the definitions given in the claims.

As opposed to the coil configuration, the antenna formed of a distally open length of wire which couples capacitively with the electromagnetic field and which forms at least a part of a guidewire for vascular procedures has the effect that the received signal originates from the immediate neighbourhood of the open wire length, whereby it becomes possible to obtain an image of the antenna, of its position, as well as of its orientation. Steering of the appliance is thus actually possible. As opposed to coil antennas for which the received signal depends on the loop diameter, the diameter of the antenna formed of a distally open length of wire which couples capacitively with the electromagnetic field and which forms at least a part of a guidewire for vascular procedures is of secondary relevance and, therefore, the antenna may be extremely thin and it may also have a high flexibility, allowing safe driving and passage through vascular configurations, even in tortuous and restricted areas thereof. This opens way to using magnetic resonance imaging procedures in interventional conditions where time and precision are of the essence. By repeatedly measuring, reconstructing, and displaying the image with a very short image repetition time, a magnetic resonance imaging fluoroscopy system can be created. And one could also use the antenna to make a high resolution image of a vessel wall.

According to a simple inexpensive embodiment, the antenna may be formed by a coaxial cable. According to an embodiment aiming very thin configurations, the antenna may be made of a coaxial cable in which the shield and insulators are respectively made of a conductor coating and insulating coatings. In both these cases, the first and second conducting elements of the coaxial configuration may have the same length or unlike lengths.

According to a further embodiment, also aiming very thin configurations, the antenna may be made of two conducting strands insulated from one another, twisted or parallel to one another. And these strands may have the same length or unlike lengths.

The antenna may be included in a catheter and the like. It may also be used for the positioning of catheters and the like.

These and other objects will become readily apparent from the following detailed description with reference to the accompanying drawings which show, diagrammatically and by way of example only, four embodiments of the invention.

Figure 1 is a block diagram of a system according to the present invention.

Figure 2 is a longitudinal part section of a first embodiment of the medical appliance.

Figure 3 is a longitudinal part section of a second embodiment of the medical appliance.

Figures 4 and 5 are longitudinal views of two further embodiments of the medical appliance.

The system shown in Figure 1 is a magnetic resonance imaging apparatus 1 comprising a magnet system 2 for generating a homogeneous magnetic field on a subject 3 placed on a support table 4. Inside the magnet system 2 is a coil structure 5 to produce around the subject a magnetic field obtained from radio-frequency energy source 6. Receiver 7 responds to the resonance signal and processor 8 reconstitutes the integers of the projection which will be shown on display 11. The medical appliance 9, inserted into subject 3, is connected via conductor 10 to control station 12. Such a general configuration is familiar to those skilled in the art and it will not be described in further detail.

The appliance 9, as exemplified in Figure 2, is a guidewire including an open wire length antenna formed by a coaxial cable comprising a central conductor 13 enclosed in an insulator 14 surrounded by a shield 15 encased in an insulator 16. The shield 15 or outer conductor and the outer insulator 16 of the coaxial cable has been removed some length from the tip or distal end 17. The proximal end (not shown) of the coaxial cable is for connection to the standard antenna input of control station 12 as generally shown in Figure 1.

The appliance 9 of Figure 3 is also a guidewire including an open wire length antenna formed by a coaxial cable. However, the insulator 14 surrounding the central conductor 130 is replaced by an insulating coating 140, while the shield 15 is replaced by a conductor coating 150 and the insulator 16 by an insulator coating 160. As for the embodiment of Figure 1, the conductor coating 150 and insulator coating 160 have been removed some length from the distal end of tip 170. Also, the proximal end (not shown) of this coaxial cable is adapted to connection to the standard antenna input of control station 12 (Figure 1).

Variants may be envisaged.

For instance, the outer conductor and insulator, 15-16 resp. 150-160, need not being removed some length from the distal end 17 resp. 170. Similarly, the outer conductor and insulator may be removed a far greater length from the distal end 17 resp. 170, being also possible to have them removed up to proximal end of the guidewire, outside of the patient.

Subject to the precautions or requirements inherent to patient protection, it would be also possible to have the guidewire comprised of a naked conductor 13 or 130, while the insulator 14 or 140 and outer conductor 15, 150 and insulator 16, 160 would be installed towards the proximal end of the guidewire, outside of

the patient.

Similarly, the coaxial configuration shown is not compulsory, being possible to have the open wire length antenna as a naked or insulated wire with appropriate polarities arranged for connection thereof to the antenna input of the control station.

Figure 4 shows one such possibilities, in which the open wire length antenna is made of two twisted conducting strands 18 and 19 insulated from one another by appropriate coatings 20 and 21.

Figure 5 also shows one such possibilities, in which the open wire length antenna is made of two conducting strands 22 and 23 parallel to one another and separated by insulator coatings 24 and 25.

As for the previous embodiments, the strands 18 and 19, respectively 22 and 23, may have the same length or unlike lengths.

In both the embodiments of Figure 4 and Figure 5, the channels 30 which are left open along the insulated strands may be used for further investigation purposes when the open wire length antenna is placed in the lumen of a catheter, for example for pressure readings.

Claims

1. A magnetic resonance imaging system for tracking a medical appliance, comprising means for performing magnetic resonance imaging procedures on a body, whereby electromagnetic waves in radio-frequency and magnetic field gradient pulses are generated and transmitted into the body to induce a resonant response signal from selected nuclear spins within the body, said system comprising a wire antenna detecting magnetic resonance response signals, the antenna being intended to be included into the medical appliance and intended to be inserted into the body for obtaining a positional picture of the antenna which can be superposed with a magnetic resonance image of the body for calculating the position of the antenna in the body, characterized in that the antenna is formed of a distally open length of wire which couples capacitively with the electromagnetic field and which forms at least a part of a guidewire for vascular procedures.

2. A system according to claim 1, wherein the antenna is formed of a coaxial cable (13, 14, 15, 16-130, 140, 150, 160).

3. A system according to claim 1 or 2, wherein the antenna is formed of a cable having a central conductor (13) enclosed in an insulator (14) surrounded by an outer conductor (15) encased in an insulator (16), and wherein said central conductor (13) and outer conductor (15) have the same length.

4. A system according to claim 1 or 2, wherein the antenna is formed of a cable having a central conductor (13) enclosed in an insulator (14) surrounded by an outer conductor (15) encased in an insulator (16), and wherein said central conductor (13) and outer conductor (15) have unlike lengths.

5. A system according to claim 1 or 2, wherein the antenna is made of a conductor (130), a first insulating coating (140) applied on said conductor, a conducting coating (150) surrounding said first insulating coating, and a second insulating coating (160) applied on said conducting coating, and wherein said conductor (130) and conducting coating (150) have the same length.

6. A system according to claim 1 or 2, wherein the antenna is made of a conductor (130), a first insulating coating (140) applied on said conductor, a conducting coating (150) surrounding said first insulating coating, and a second insulating coating (160) applied on said conducting coating, and wherein said conductor (130) and conducting coating (150) have unlike lengths.

7. A system according to claim 1 wherein the antenna is made of two conducting strands (18, 19-22, 23) insulated from one another (20, 21-24,25).

8. A system according to claim 7, wherein the two strands (22, 23) are parallel to one another.

9. A system according to claim 7, wherein the two strands (18, 19) are twisted.

10. A system according to any of claims 7 to 9, wherein the two strands (18, 19-22, 23) have the same length.

11. A system according to any of claims 7 to 9, wherein the two strands (18, 19-22, 23) have unlike lengths.

Patentansprüche

1. Magnetisches Resonanzdarstellungssystem zur Verfolgung einer medizinischen Vorrichtung mit Mitteln zur Durchführung von Verfahren der magnetischen Resonanzdarstellung eines Körpers, bei welchen elektromagnetische Hochfrequenzwellen und magnetische Feldgradientenpulse erzeugt werden und in den Körper gesendet werden, um ein Resonanzantwortsignal von ausgewählten Kernspins innerhalb des Körpers zu induzieren, wobei das System eine Drahtantenne für die Erfassung der magnetischen Resonanzantwortsignale umfaßt, wobei die Antenne dafür bestimmt ist, in die medizinische Vorrichtung aufgenommen zu werden und dafür bestimmt ist, in den Körper eingeführt zu werden, um ein Positionsbild der

Antenne zu erhalten, welches dem magnetischen Resonanzbild des Körpers überlagert werden kann, um die Position der Antenne in dem Körper zu errechnen,
dadurch gekennzeichnet, daß
die Antenne aus einer in der Richtung von der Körpermitte weg offenen Drahtlänge gebildet wird, welche mit dem elektromagnetischen Feld kapazitiv koppelt und welche zumindest einen Teil eines Führungsdrahts für Gefäßverfahren bildet.

2. System nach Anspruch 1, wobei die Antenne aus einem koaxialen Kabel (13, 14, 15, 16 - 130, 140, 150, 160) gebildet wird.

3. System nach Anspruch 1 oder 2, wobei die Antenne aus einem Kabel mit einem zentralen Leiter (13), der in einem Isolator (14) eingeschlossen ist, welcher von einem äußeren Leiter (15) umgeben ist, der von einem Isolator (16) ummantelt ist, gebildet wird und wobei der zentrale Leiter (13) und der äußere Leiter (15) dieselbe Länge aufweisen.

4. System nach Anspruch 1 oder 2, wobei die Antenne aus einem Kabel mit einem zentralen Leiter (13), der in einem Isolator (14) eingeschlossen ist, welcher von einem äußeren Leiter (15) umgeben ist, der von einem Isolator (16) ummantelt ist, gebildet wird und wobei der zentrale Leiter (13) und der äußere Leiter (15) voneinander verschiedene Länge aufweisen.

5. System nach Anspruch 1 oder 2, wobei die Antenne aus einem Leiter (130), einer ersten, auf dem Leiter angebrachten Isolierschicht (140), einer die erste Isolierschicht umgebende Leiterschicht (150) und einer zweiten, auf der Leiterschicht angebrachten Isolierschicht (160) besteht und wobei der Leiter (130) und die Leiterschicht (150) dieselbe Länge aufweisen.

6. System nach Anspruch 1 oder 2, wobei die Antenne aus einem Leiter (130), einer ersten, auf dem Leiter angebrachten Isolierschicht (140), einer die erste Isolierschicht umgebende Leiterschicht (150) und einer zweiten, auf der Leiterschicht angebrachten Isolierschicht (160) besteht und wobei der Leiter (130) und die Leiterschicht (150) voneinander verschiedene Längen aufweisen.

7. System nach Anspruch 1, wobei die Antenne aus zwei Leitersträngen (18, 19 - 22, 23) besteht, welche voneinander isoliert sind (20, 21 - 24, 25).

8. System nach Anspruch 7, wobei die beiden Stränge (22, 23) zueinander parallel verlaufen.

9. System nach Anspruch 7, wobei die beiden Stränge (18, 19) verdrillt sind.

10. System nach einem der Ansprüche 7 bis 9, wobei die beiden Stränge (18, 19 - 22, 23) dieselbe Länge aufweisen.

11. System nach einem der Ansprüche 7 bis 9, wobei die beiden Stränge (18, 19 - 22, 23) voneinander verschiedene Längen aufweisen.

Revendications

1. Système d'imagerie par résonance magnétique pour réaliser un suivi d'un appareil médical, comprenant un moyen pour réaliser des procédures d'imagerie par résonance magnétique sur un corps de telle sorte que des ondes électromagnétiques haute fréquence et que des impulsions de gradient de champ magnétique soient générées et transmises dans le corps afin d'induire un signal de réponse de résonance à partir de spins nucléaires sélectionnés à l'intérieur du corps, ledit système comprenant une antenne filaire qui détecte des signaux de réponse de résonance magnétique, l'antenne étant destinée à être incluse dans l'appareil médical et à être insérée dans le corps pour obtenir une image de position de l'antenne qui peut être superposée sur une image de résonance magnétique du corps pour calculer la position de l'antenne dans le corps, caractérisé en ce que l'antenne est formée par une longueur de fil ouverte de façon distale qui est coupée de manière capacitive au champ électromagnétique et qui forme au moins une partie d'un fil de guidage pour des procédures vasculaires.

2. Système selon la revendication 1, dans lequel l'antenne est formée par un câble coaxial (13, 14, 15, 16-130, 140, 150, 160).

3. Système selon la revendication 1 ou 2, dans lequel l'antenne est formée par un câble comportant un conducteur central (13) enfermé dans un isolant (14) entouré par un conducteur externe (15) enfermé dans un isolant (16) et dans lequel ledit conducteur central (13) et ledit conducteur externe (15) présentent les mêmes longueurs.

4. Système selon la revendication 1 ou 2, dans lequel l'antenne est formée par un câble comportant un conducteur central (13) enfermé dans un isolant (14) entouré par un conducteur externe (15) enfermé dans un isolant (16) et dans lequel ledit conducteur central (13) et ledit conducteur externe (15) présentent des longueurs différentes.

5. Système selon la revendication 1 ou 2, dans lequel l'antenne est constituée par un conducteur (130),

un premier revêtement isolant (140) appliqué sur ledit conducteur, un revêtement conducteur (150) entourant ledit premier revêtement isolant et un second revêtement isolant (160) appliqué sur ledit revêtement conducteur, et dans lequel ledit conducteur (130) et ledit revêtement conducteur (150) présentent la même longueur.

6. Système selon la revendication 1 ou 2, dans lequel l'antenne est constituée par un conducteur (130), un premier revêtement isolant (140) appliqué sur ledit conducteur, un revêtement conducteur (150) entourant ledit premier revêtement isolant et un second revêtement isolant (160) appliqué sur ledit revêtement conducteur, et dans lequel ledit conducteur (130) et ledit revêtement conducteur (150) présentent des longueurs différentes.

7. Système selon la revendication 1, dans lequel l'antenne est constituée par deux brins conducteurs (18, 19-22, 23) isolés l'un de l'autre (20, 21-24, 25).

8. Système selon la revendication 7, dans lequel les deux brins (22, 23) sont parallèles l'un à l'autre.

9. Système selon la revendication 7, dans lequel les deux brins (18, 19) sont torsadés.

10. Système selon l'une quelconque des revendications 7 à 9, dans lequel les deux brins (18, 19-22, 23) présentent les mêmes longueurs.

11. Système selon l'une quelconque des revendications 7 à 9, dans lequel les deux brins (18, 19-22, 23) présentent des longueurs différentes.

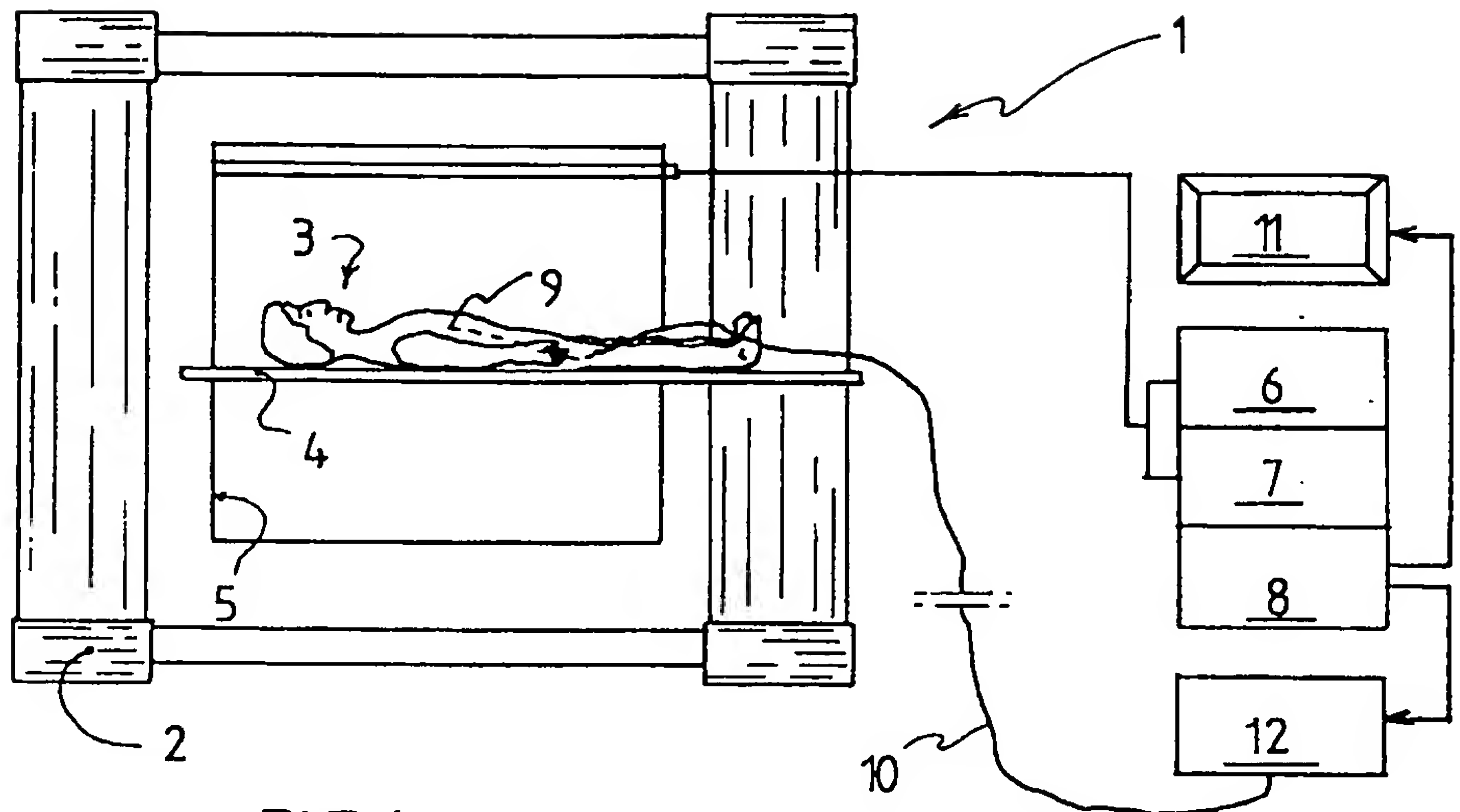

FIG.1

FIG. 2

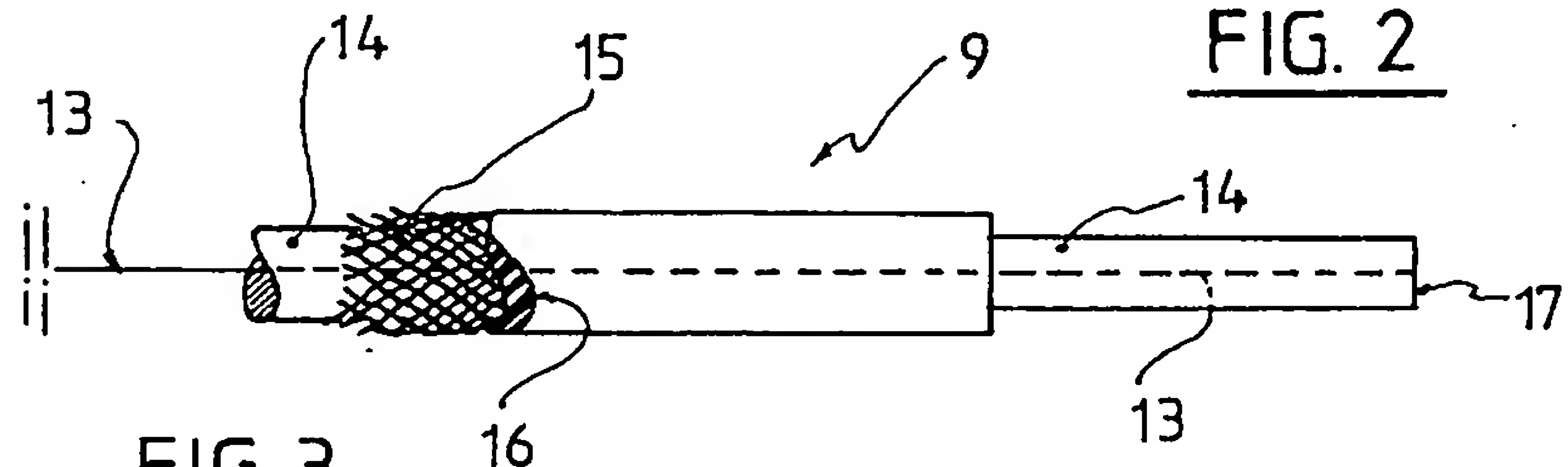

FIG. 3

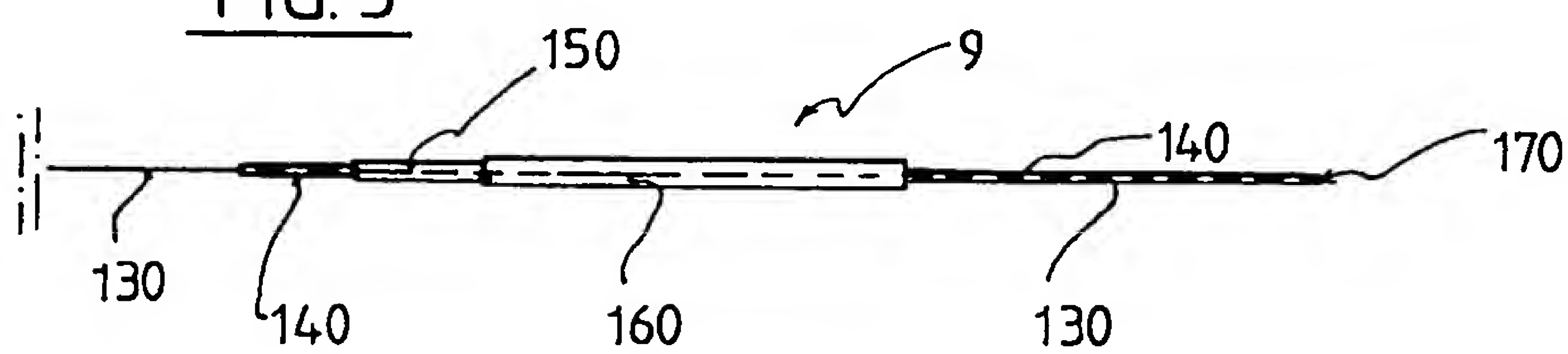

FIG. 4

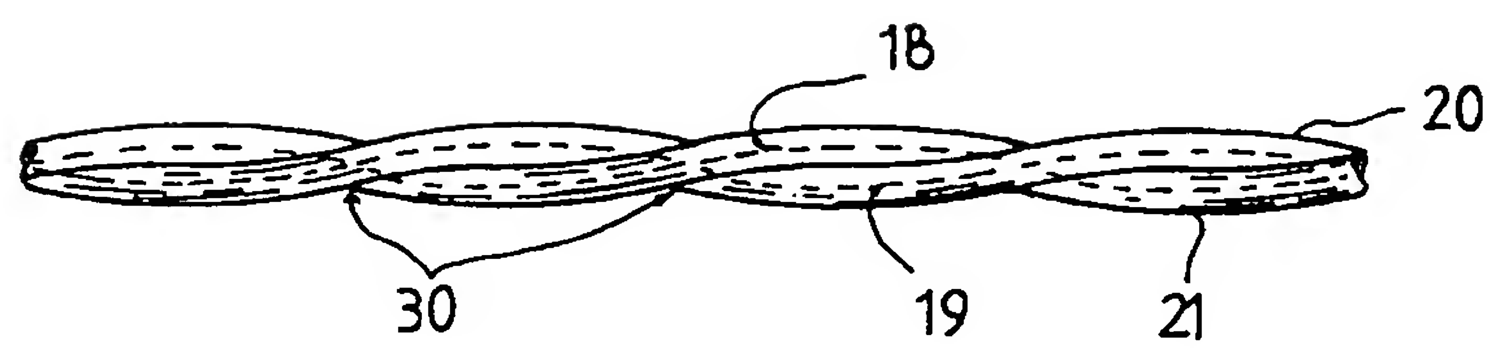

FIG. 5